

What is claimed is:

1. In a broad-band spread spectrum communications system wherein a transmitter transmits a data modulated MPSK spread spectrum radio frequency (RF) signal, where  $m$  data bits are grouped into one symbol,  $m = \log_2 M$  is a positive integer and  $M$  is the number of keying phases of MPSK signals, to a receiver, said receiver comprises:

means for receiving the transmitted data modulated MPSK spread spectrum RF signals, wherein the receiving means comprises a carrier recovery and tracking means, a synchronization means and a data demodulation means.

2. The receiver of claim 1, wherein the carrier recovery and tracking means comprises:

a frequency generating means which generates three different frequencies  $f_c + D$ ,  $f_c$  and  $f_c - D$ , where  $f_c$  represents the adjusted carrier frequency and  $D$  a positive offset to  $f_c$ ;

two RF downconverters, each of which comprises two multipliers and a  $90^\circ$  phase shifter. Each down-converter has two inputs, one connected to receive the transmitted data modulated MPSK spread spectrum signals and the other one connected to receive the locally generated carrier from said frequency generator, and two outputs which provide the I-phase and Q-phase of the base-band signals. One downconverter is connected to receive  $f_c + D$  from said frequency generating means and the other one is connected to receive  $f_c - D$  from said generating means;

two X-correlators each connected to receive said I-phase and Q-phase of the base-band signals. The I-phase and Q-phase signals are correlated with the local PN-sequence. The correlation results are processed and outputs from the two X-correlators are used to adjust the frequency generated by the VCO which output in turn is fed to said frequency generating means.

3. The frequency generating means of claim 2 consists of three ROM look-up tables which store the locally generated carrier clock values. The outputs from look-up tables are converted by D/A converter means to generate three different frequencies  $f_c + D$ ,  $f_c$  and  $f_c - D$ , where  $f_c$  represents the adjusted frequency and  $D$  a positive offset to  $f_c$ ;

4. Each X-correlator of claim 2 comprises two shift registers, a PN generator, two correlators, two square operator circuits, two summers and a storage means for storing a threshold value. The parallel shift registers are connected to receive said I- phase and Q-phase of the base-band signals from downconverters of claim 2. Said received I-phase and Q-phase signals are correlated with the local PN-sequence. The correlation results from each of the two correlators are squared, summed and compared with a preset threshold value to obtain the correlation peak value. Said correlation peak value is the output of the X-correlator.

5. The frequency generated by said VCO of claim 2 is controlled by two X-correlators of claim 4. The difference between output values of the two X-correlators are amplified and averaged by a low pass filter to form an error signal which is fed to the input of the VCO. The VCO frequency clock is increased when the error is positive and decreased when the error is negative.

6. The receiver of claim 1, wherein the synchronization means comprises N storage means,  $R_1, R_2, \dots, R_N$  and a subtractor where N is an odd number. The output from one of the said X-correlators of claim 2 is sampled N times per chip, where N is an odd integer greater or equal to three. The sampled values are stored in sequence in the N-storage means  $R_1, R_2, \dots, R_N$ . The difference between the sample stored in  $R_1$  and the sample store in  $R_N$  forms the phase error of the chip clock. The sample store in  $R_{(N-1)/2}$  is used for coarse synchronization of the symbol clock.

7. The receiver part of claim 1, wherein the data demodulation means comprises:

a RF down-converter, which include a  $90^\circ$  phase shifter connected to receive the transmitted data modulated MPSK spread spectrum signal. Said down-converter has two inputs, one connected to receive the transmitted data modulated MPSK spread spectrum signals and the other one connected to receive the locally generated carrier  $f_c$  from said frequency generator of claim 2, and two outputs which provide the I- and Q-phases of the base-band signals;

two match filters each connected to said I- phase and Q- phases of the base-band signals;

two one-data-bit-delay-line each connected to the outputs of said match filters;

four multipliers, two summers and a phase-table which stores the M-phase values of MPSK modulation.

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8. Data demodulation in the data demodulation means of claim 7 comprises the following steps:

the received data modulated MPSK spread spectrum RF signal is down-converted by the carrier frequency  $f_c$  from said frequency generator of claim 2  
10 into I-channel and Q-channel signals;

said match filters of claim 7 de-spread said I-channel and Q-channel signals;

said de-spreaded I-channel and Q-channel signals are multiplied by their own one-bit-delayed signal and the sum of these two multiplications produce  
15 the real-part of the phase information for demodulation, denoted by COS;

said de-spreaded I-channel signal is multiplied with the one-bit-delayed said de-spreaded Q-channel signal while said de-spreaded Q-channel signal is multiplied with the one-bit-delayed said de-spreaded I-channel signal. The difference between the two multiplications produce the imaginary-part of the phase  
20 information for demodulation, denoted by SIN;

said SIN and COS signals form a phase pair (COS, SIN). After normalization, the phase pair  $(\text{COS}, \text{SIN})_{\text{norm}}$  is compared with modulating phases stored in said phase-table of claim 7;

The phases stored in said phase-table of claim 7 are compared with  
25 the normalized phase pair  $(\text{COS}, \text{SIN})_{\text{norm}}$ . The one that is closest to the phase pair  $(\text{COS}, \text{SIN})_{\text{norm}}$  is chosen as the demodulated phase.

9. The measure of closeness of said  $(\text{COS}, \text{SIN})_{\text{norm}}$  with phases stored in said phase-table in claim 8 is the Euler distance measure.

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